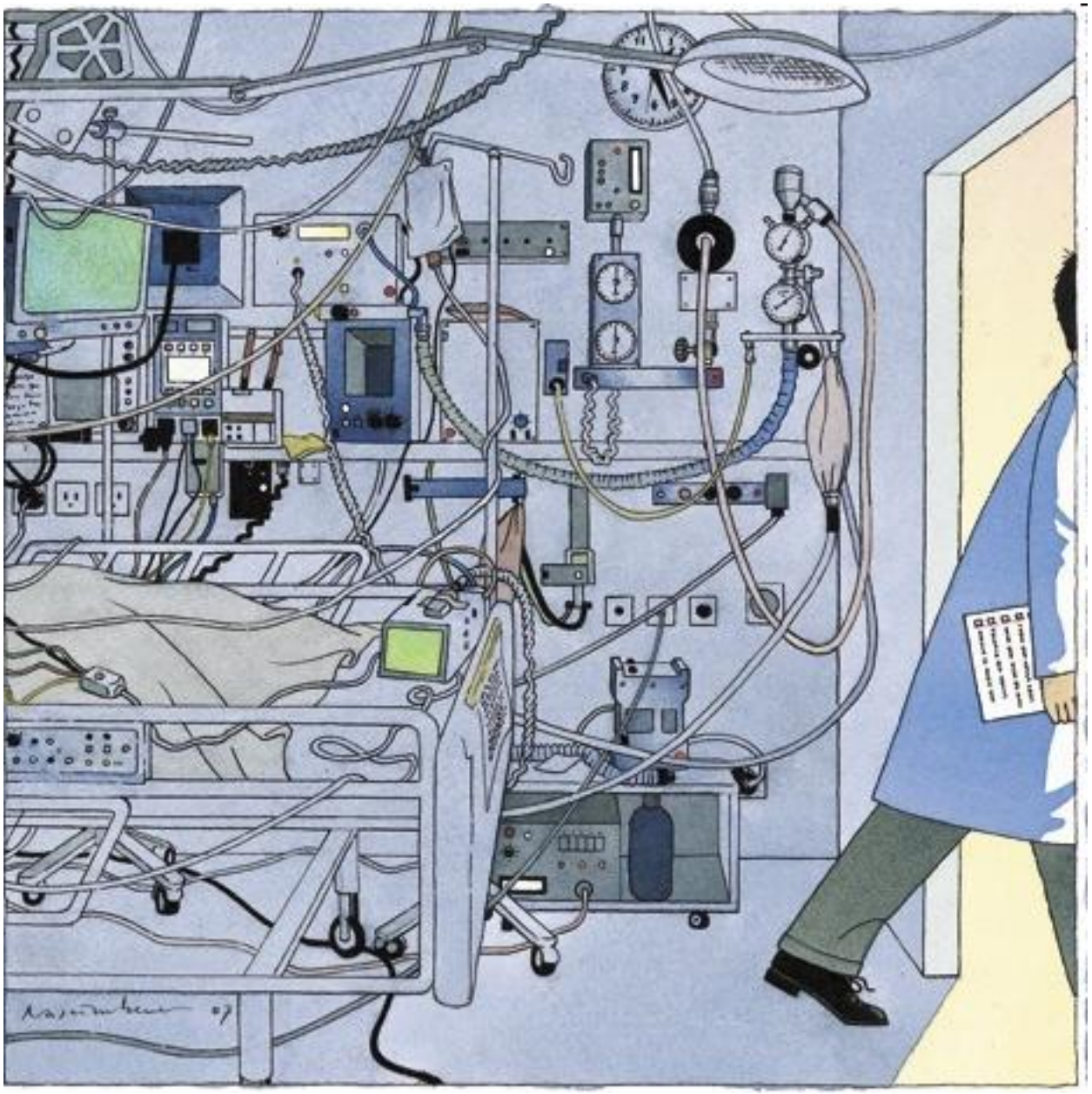
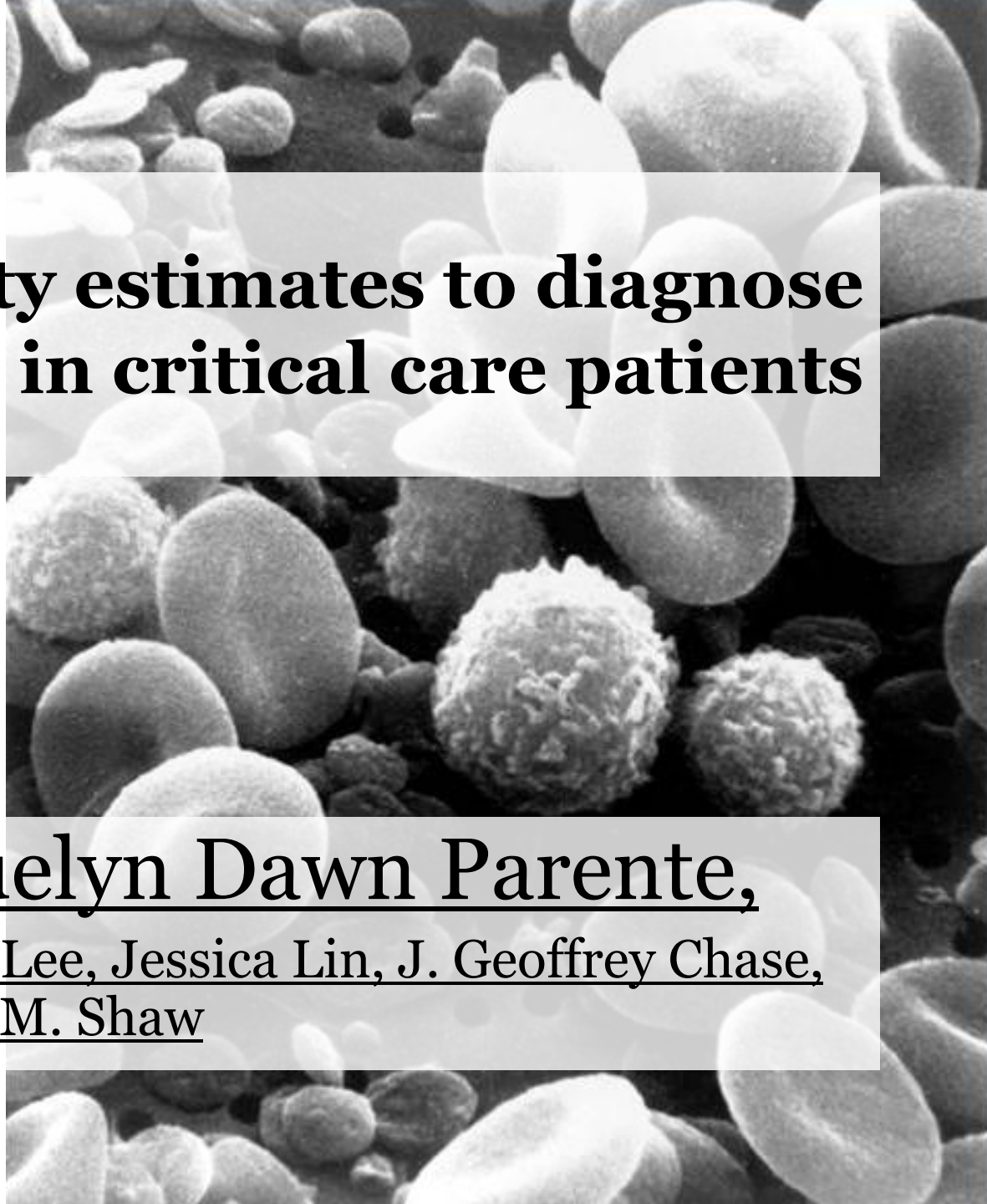


Kernel density estimates to diagnose sepsis in critical care patients



UNIVERSITY OF CANTERBURY
Te Whare Wānanga o Waitaha
CHRISTCHURCH NEW ZEALAND

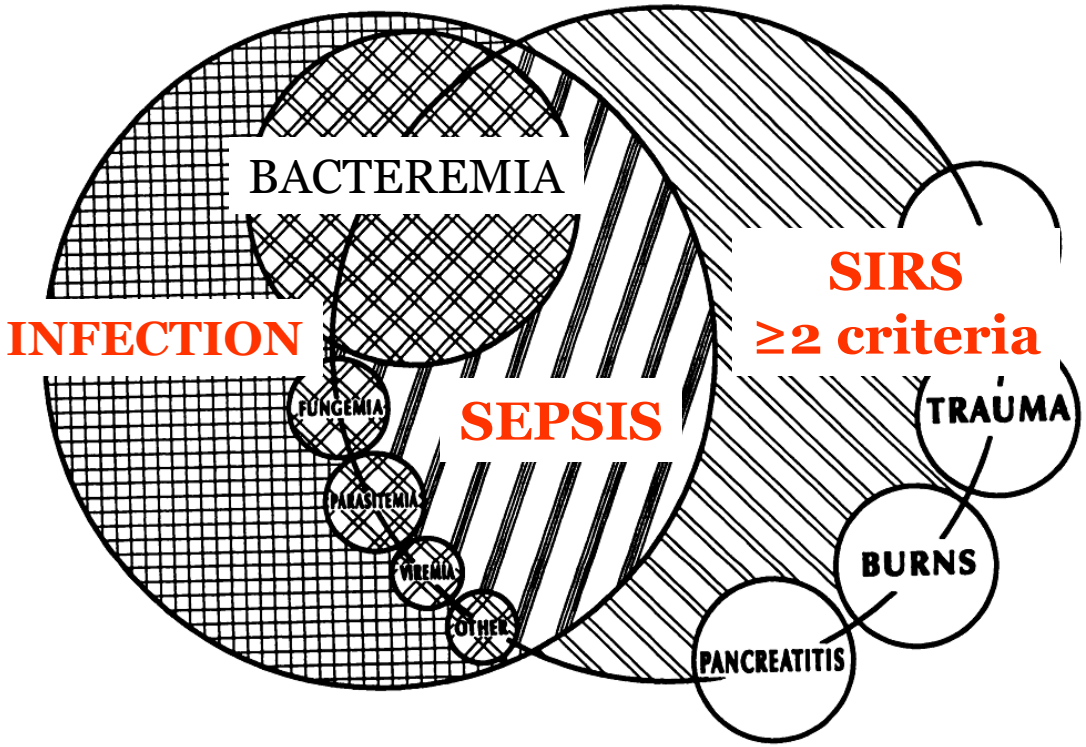
UC BIOENGINEERING

Canterbury District Health Board
Te Poari Hauora ō Waitaha

Jacquelyn Dawn Parente,

Dominic Lee, Jessica Lin, J. Geoffrey Chase, Geoffrey M. Shaw

Sepsis is systemic inflammation due to infection.



Systemic Inflammatory Response Syndrome (SIRS)			
Temperature < 36 C > 38 C	Heart rate > 90 beats/min	Respiratory rate or $PaCO_2$ > 20 breaths/min < 32 mm Hg	White blood cell count < 4 x 10^9/L > 10% immature granulocytes

We aim to diagnose ‘severe’ sepsis (patients with organ system failure).

Neurologic

Respiratory

Cardiovascular

Hepatic

Renal

Hematologic

Severe sepsis is common, often kills, and expensive in New Zealand ICUs.

11.8% incidence
1.5% increase (projected)

26.5% mortality
0.67% increase

0.77 per 1000
NZ population

NZD$100M annually

Sepsis is the 10th leading cause of death in the USA.

6% of all deaths in the USA are sepsis-related (1999 to 2005).

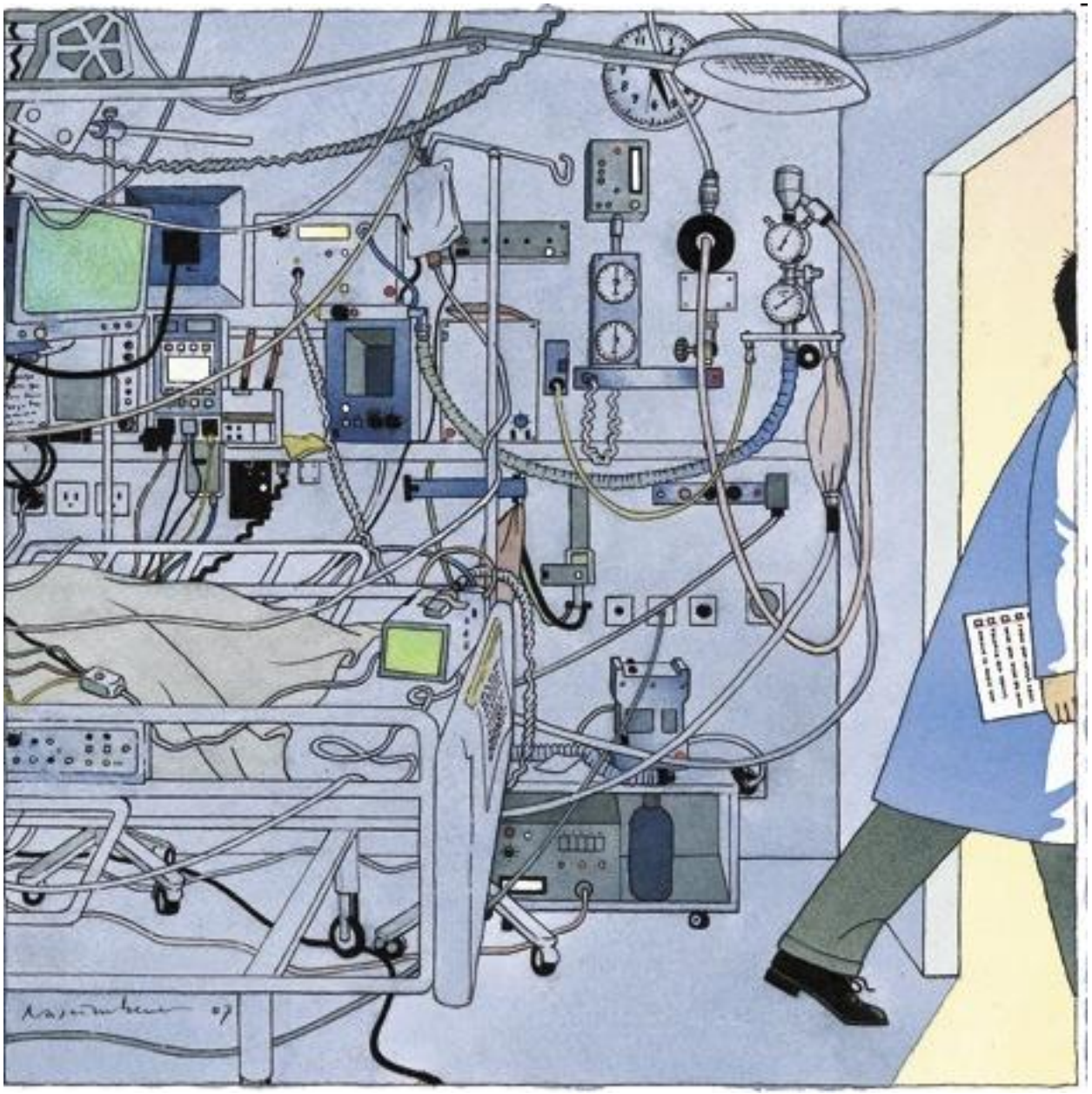
Standard sepsis diagnostics are slow, innacurate, and measured once daily.

Treat confirmed sepsis within 6h.

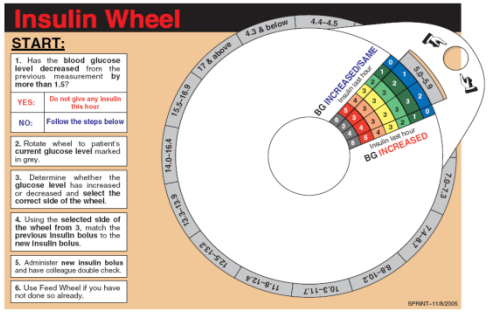
american society for microbiology

<u>Blood culture (24-48h)</u>
51% of sepsis are culture-identified

<u>PCT biomarker (0.5-2.5h)</u>
42-97% of sepsis diagnosed
43-100% of no sepsis diagnosed

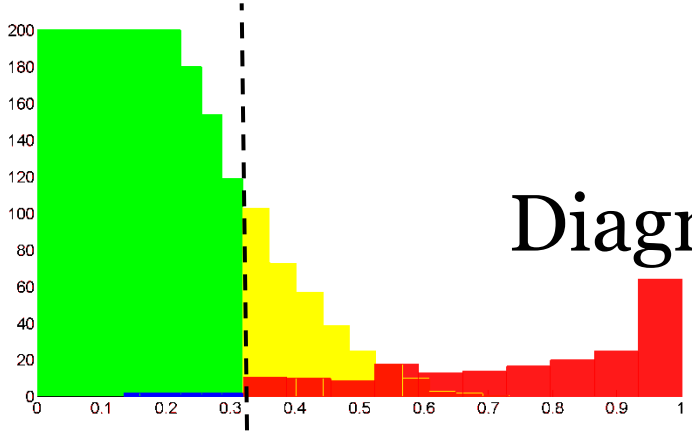


Our sepsis biomarker:



Clinical motivation

Biomarker development



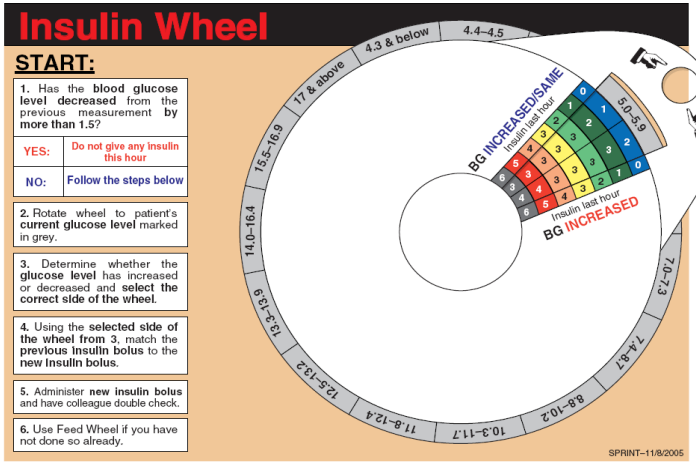
Diagnostic performance

PCT comparison

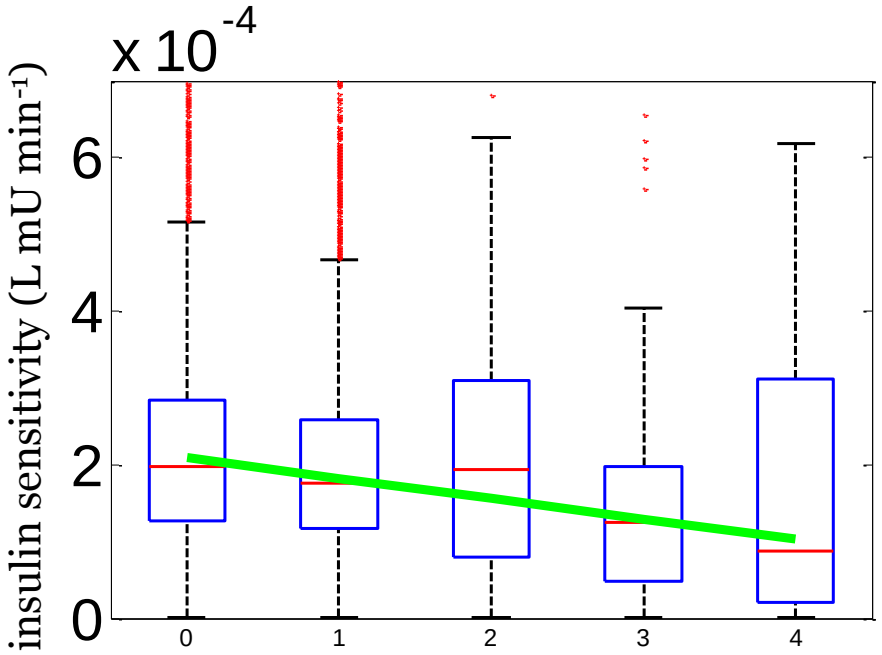
Insulin sensitivity may be a useful sepsis biomarker.

Glucose control decreased sepsis incidence.

The NEW ENGLAND JOURNAL of MEDICINE



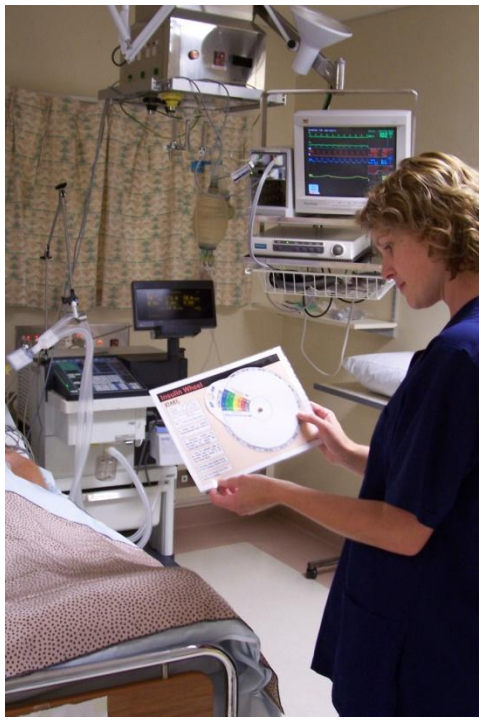
Insulin sensitivity can be measured hourly.



Insulin sensitivity decreases with illness.

Our biomarker includes hourly insulin sensitivity and bedside measurements.

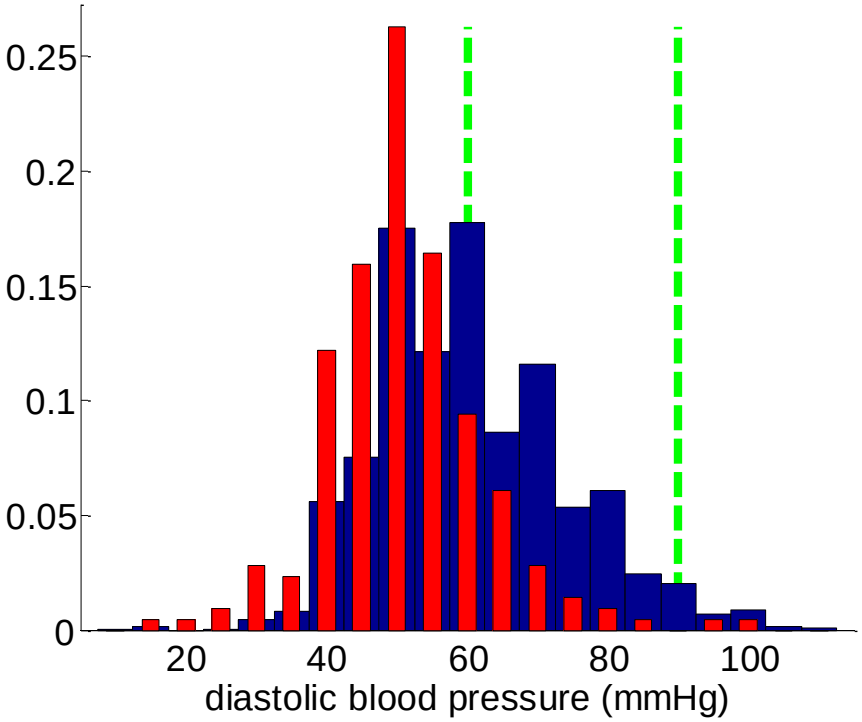
36 patients with sepsis
(6000 hours of data)



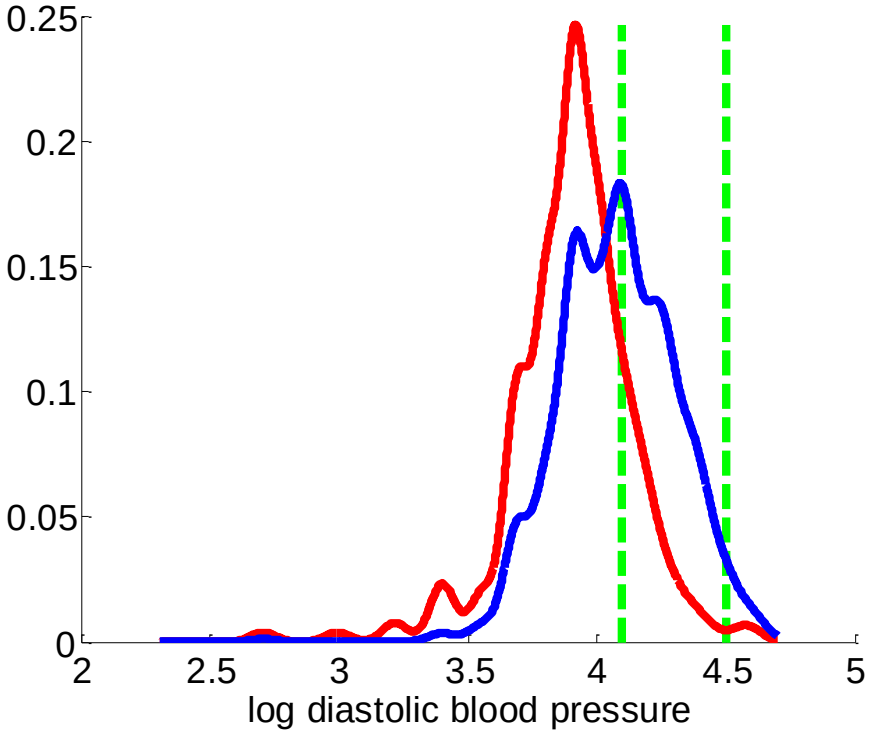
insulin sensitivity
+
SIRS
temperature,
blood pressure,
heart rate,
respiratory rate
hourly changes

Kernel density estimates provide joint probability density profiles for data hours and classification.

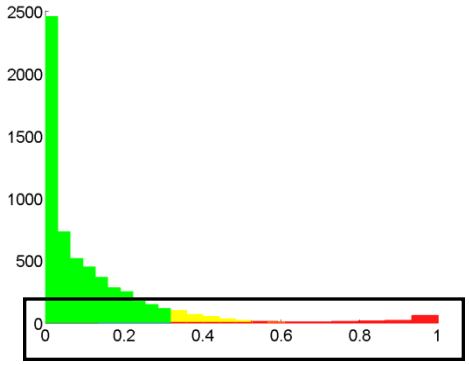
Raw data



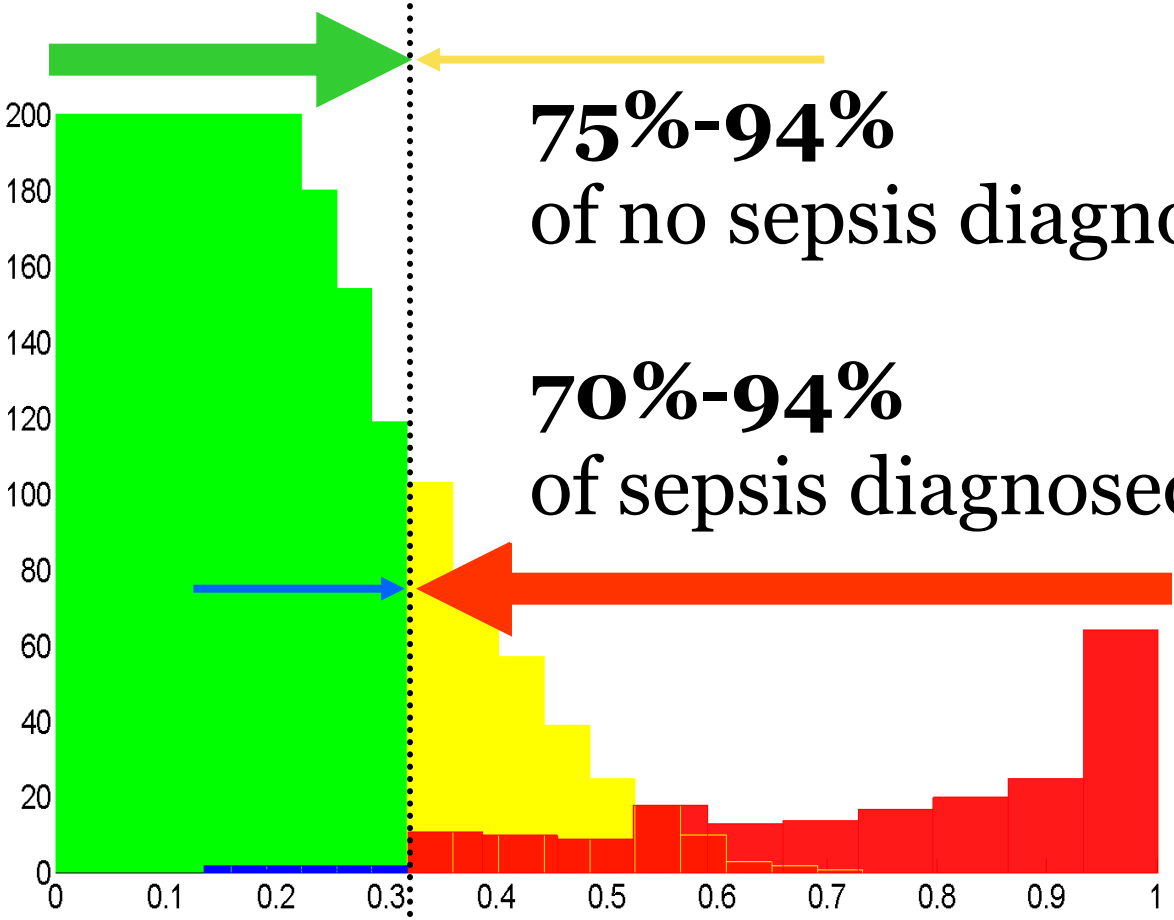
Kernel density



Our biomarker identifies the majority of sepsis AND no sepsis hours.



True Negative
False Negative
True Positive
False Positive



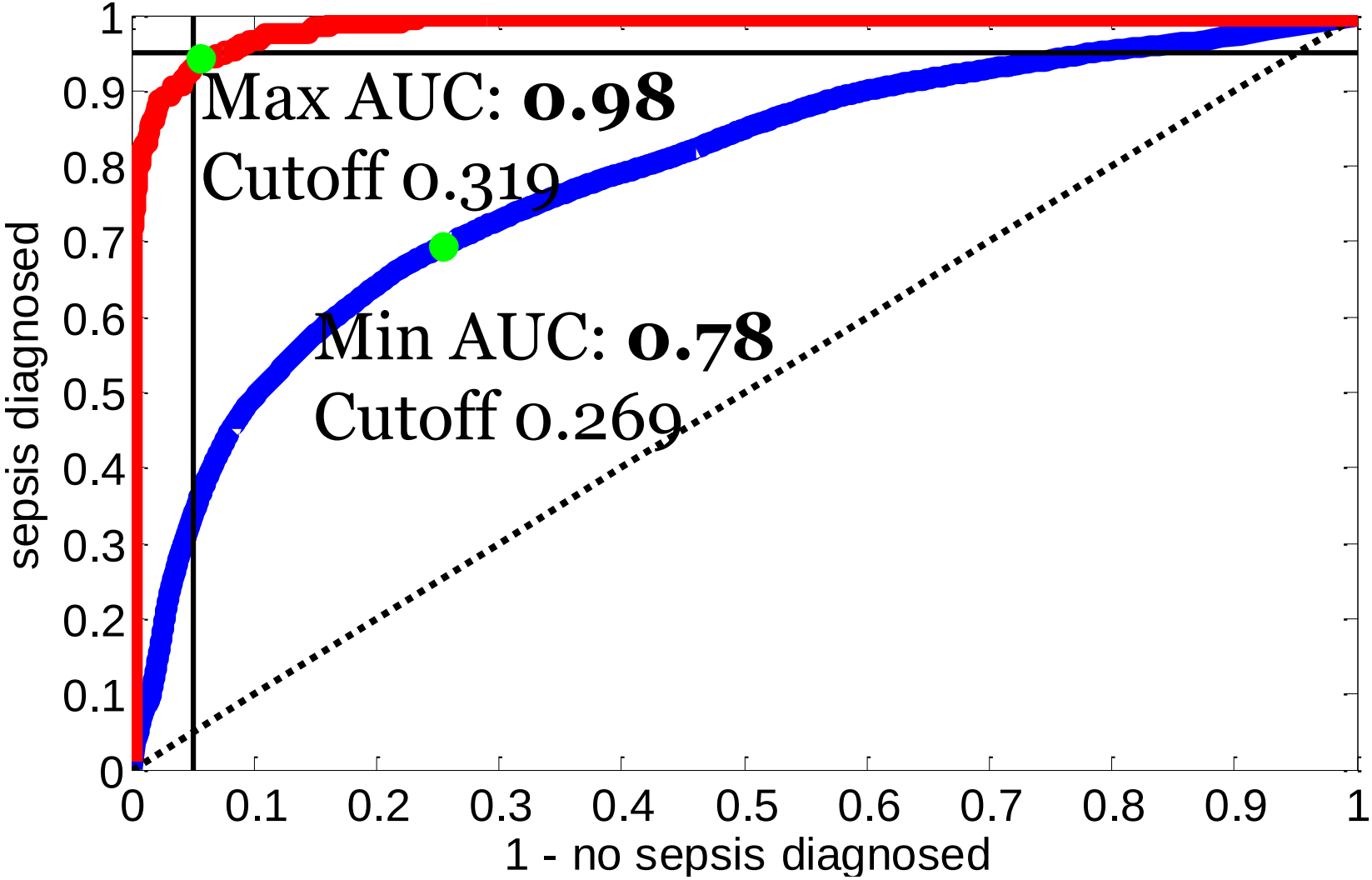
75%-94%
of no sepsis diagnosed

70%-94%
of sepsis diagnosed

99% - 100%
- outcomes correct

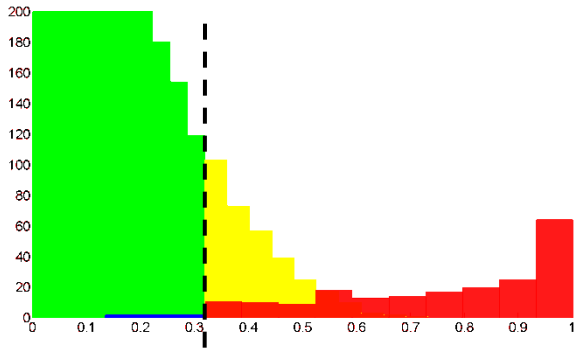
9% - 38%
+ outcomes correct

Our biomarker classification model area under the ROC curve (AUC) shows high accuracy.

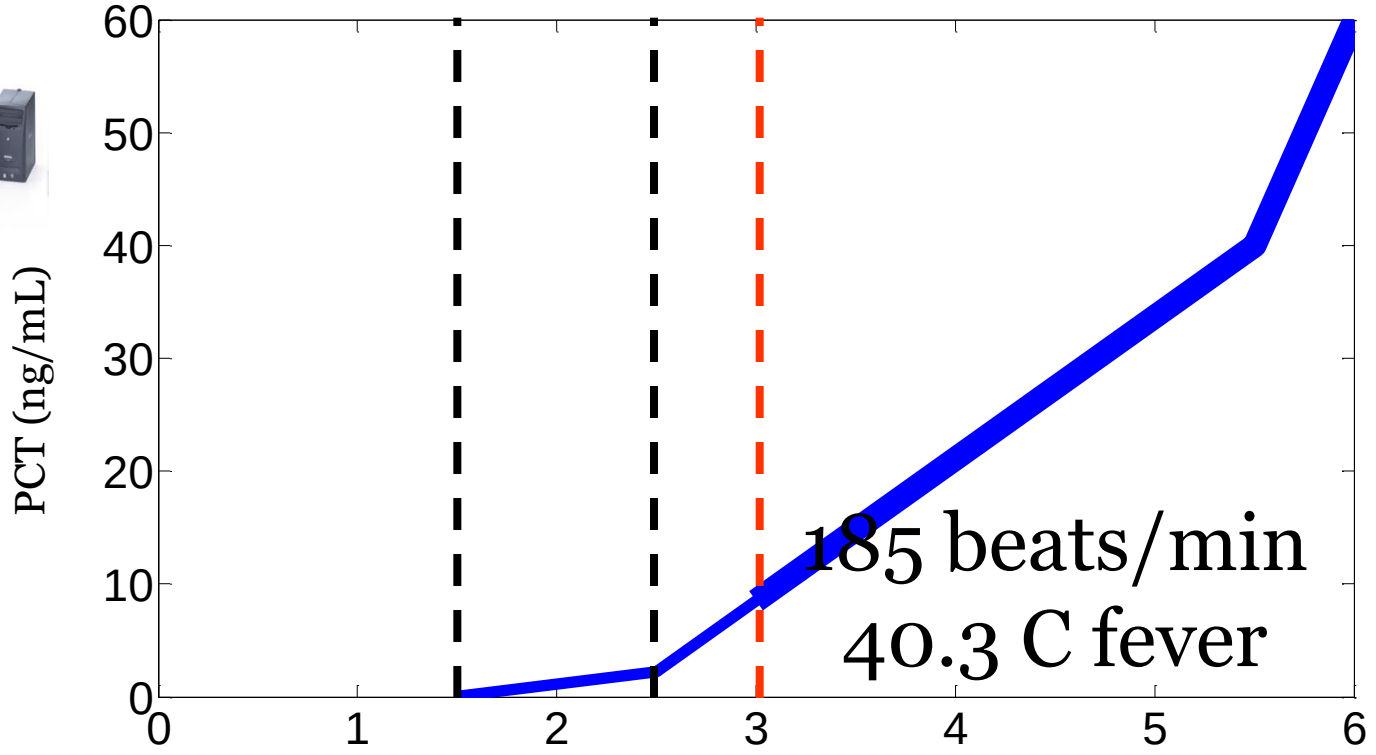


Our biomarker is more accurate than blood culture and PCT.

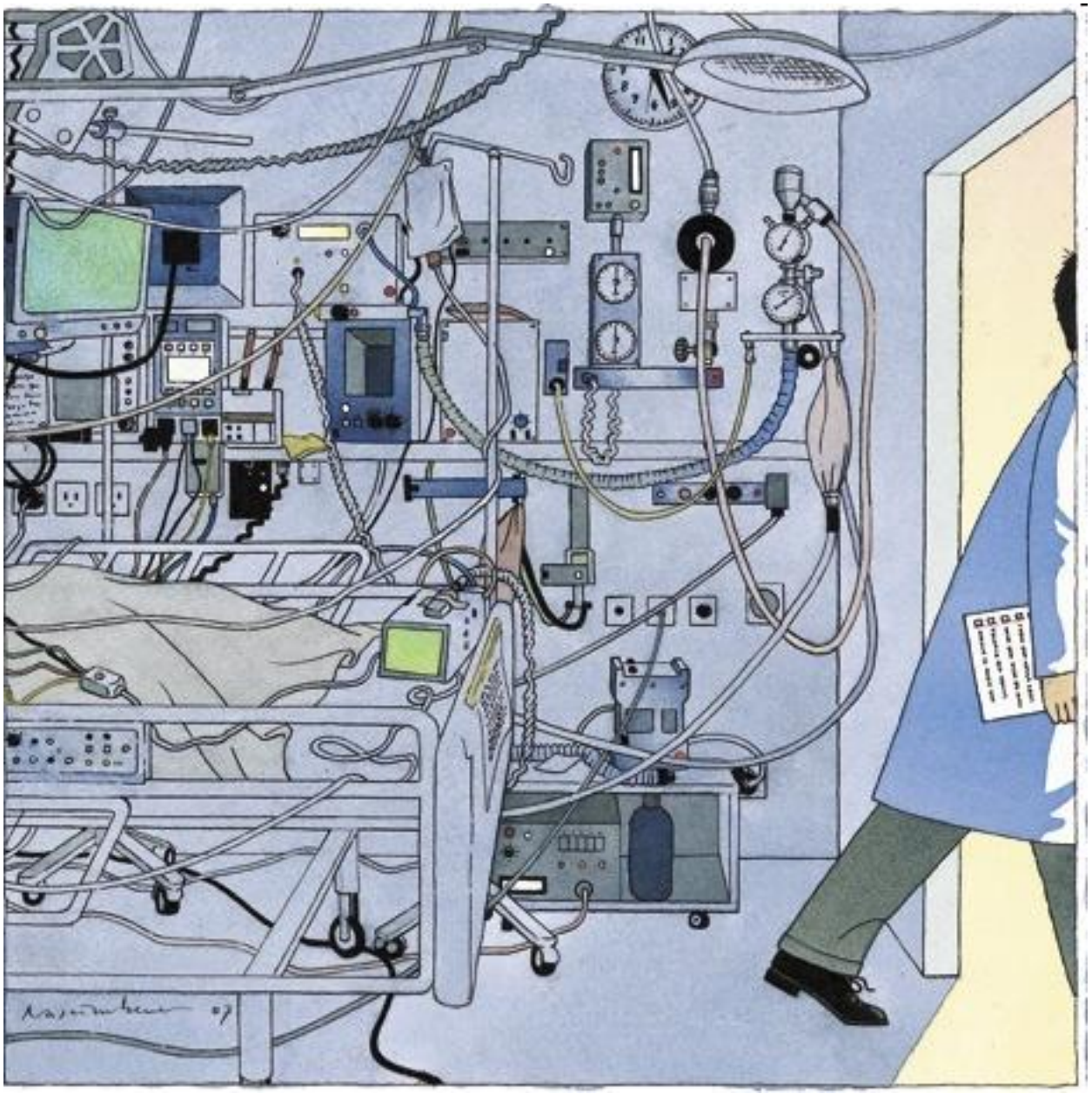
Correct Diagnosis	Culture	PCT	Biomarker
Sepsis	51%	42% - 97%	**70% - 94%**
No sepsis		43% - 100%	**75% - 94%**



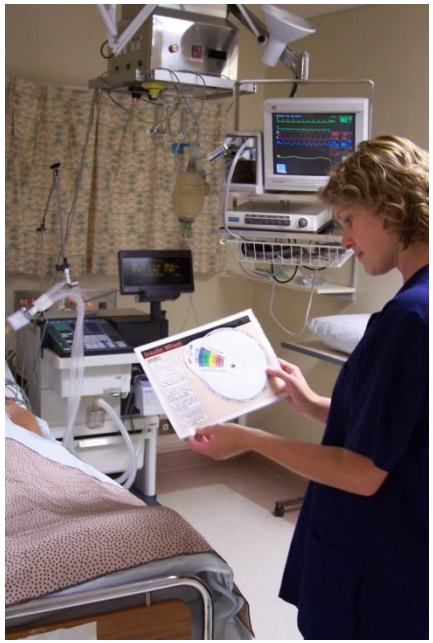
Our hourly biomarker may be faster than PCT.



PCT identified sepsis and treatment began 3h after infection.



Our sepsis biomarker diagnoses severe sepsis more quickly and accurately than existing diagnostic methods.



Treat confirmed sepsis within 6h.

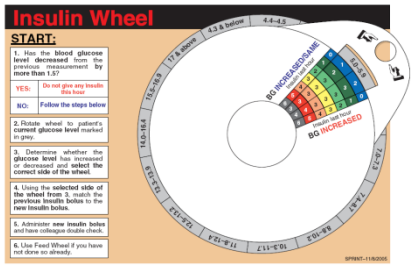
We confirmed 70%-94% of sepsis AND 74% -94% of no sepsis in 1h.

May reduce sepsis mortality, costs, and antibiotic resistance.

May improve quality of care.

Ongoing work

Clinical trial
(Aug 2009 – ongoing)
PCT vs Biomarker



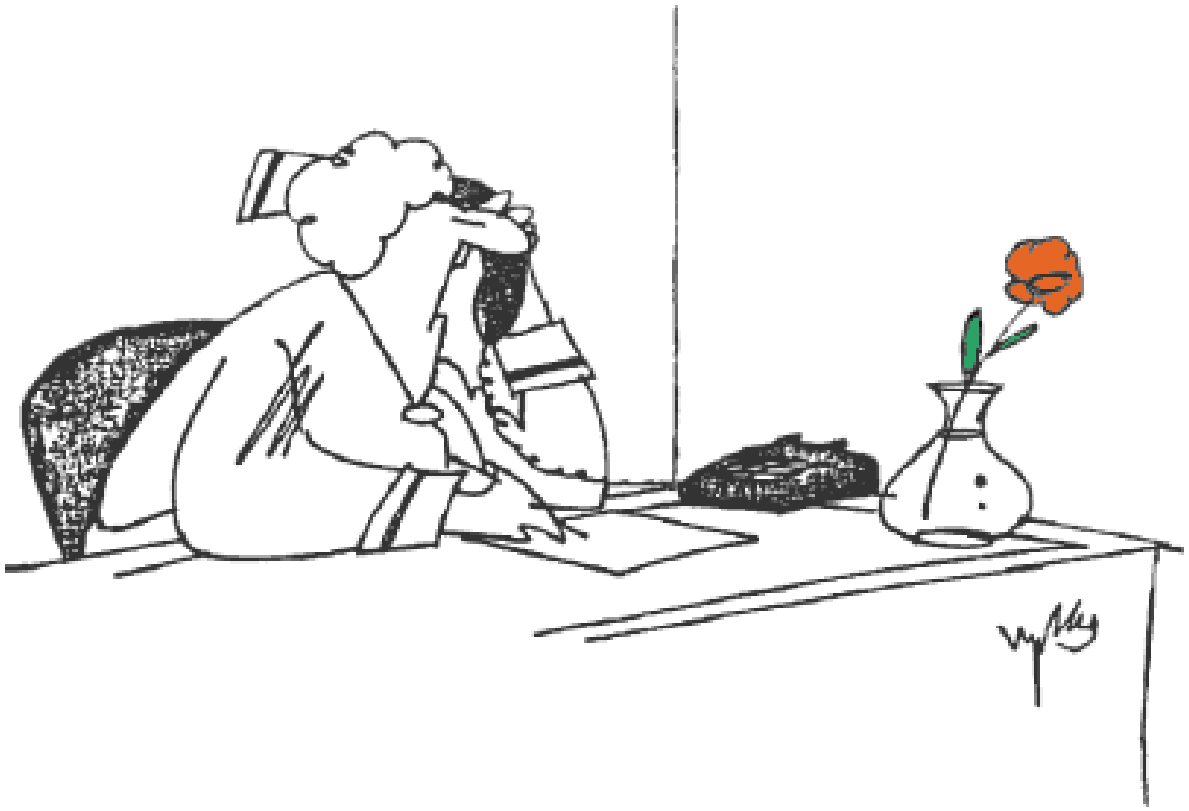
Describe sepsis evolution in time.

Validation trial.

Guide antibiotic therapy.

Reduce mortality.

Questions?



"The doctor isn't in right now. When you hear the beep, please leave your name, number and a short diagnosis."